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13. ABSTRACT

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An early "bare-bones" version of the remote conferencing system has been implemented, which has minimal capabilities--remote respondents answering questionnaires. The required programs are being structured in modular form. The addition of new modules to be incorporated in the later program releases will permit more flexibility in the group-via-computer interaction.

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Semiannual Technical Report

5 October 1972

ARPA POLICY-FORMULATION INTERROGATION NETWORK

Contract No. DAHC 15 72 C 0165

Sponsored By:

Advanced Research Projects Agency

DDC
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SUMMARY

This project, which seeks to develop a group-via-computer interrogation network, is progressing according to schedule and budget. Most of the first six months' effort has been spent writing code. Hence, there is little of significance to report at this early stage of the project other than the usual descriptions of program structures and the minor problems of transient interest common to any computer system development.

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CONTENTS

I. INTRODUCTION

This is the first semiannual Technical Report describing work in progress on a two-year study concerned with the development of a group interrogation network for policy formulation. It summarizes the work completed during the period from March 6 to September 6, 1972.

OBJECTIVES

This project seeks to develop a geographically distributed group-via-computer management tool. New equipment is to be designed and programs are to be written to automate the extraction and collation of expert opinion.

The thrust of the present phase in this project is to develop new computer-based techniques for the rapid extraction and evaluation of judgments from geographically dispersed expert participants, but where full decision-making power must be reserved by a single executive responsible for the decision.

This line of research and development is not entirely new, and major efforts in this field have gone before. Where we hope that our work will differ from earlier efforts is in that we seek to develop a "practical" system that will be useful as a real-world, real-time management tool. The acid test of practicality is whether the system will in fact be employed by management in their day-to-day operations.

Within three months after the start of this project, we were able to have a simple mock-up demonstration. But a mock-up demonstration and a real-world system are, of course, miles apart--as a management tool the system lacks many ingredients required to be a truly viable system. During the course of this project, we seek to reduce this distance between today's state of the art and the requirements of a practical, usable system, by new computer software developments and proposed hardware configurations.

RELEVANCE TO ARPA-IPT

While some of the reported activity is concerned with people-to-machine interaction and new management tools and applications, its emphasis, in line with ARPA-IPT's specific interest in the computer and communications aspects of the system, is on hardware and associated software development.

To augment the work for ARPA-IPT and to expand its scope in the direction of man-machine interaction and applications both to the collection of judgmental data and to computer-aided scientific collaboration at a distance, we have received a three-year grant from the Office of Computing Activity of the National Science Foundation. The two projects are differentiated (in simplified terms) in that the ARPA activity is directed toward the development of the computer-based system elements themselves, whereas the work on behalf of NSF is concerned mainly with the exploration of group problem-solving efforts with the aid of a computer network.

PROJECT STAFF

Responsibility for supervision of specific aspects of this project is divided as follows: Mr. Paul Baran, direction of the system design; Dr. Roy Amara, supervisory and administrative management; and Dr. Olaf Helmer, design and performance of experiments on the system.

The bulk of the work on this project and the total programming effort are being performed by Dr. Hubert Lipinski, Mr. Richard Miller, and Mr. Robert Randolph of the Institute, with the occasional assistance of Mr. John Melvin, currently at the RAND Corporation, and Dr. Rainer Schulz at Stanford University.

II. PROGRAM ORGANIZATION

COMPUTER USED

The programs are primarily written in assembly language for the PDP-10 operating under the TENEX operating system. This system is available to ARPANET users in a number of installations. (We initially used the PDP-10 at RAND but temporarily switched over to the one at BBN because of a reliability problem that occurred when we addressed the RAND system via our local TIP at Ames.)

MODULES

The programs are written as a set of packages or modules. Modules are called up as needed during the semiunpredictable course of the unfolding group-via-computer interaction.

SPECIFICATION OF THE MODULES

The specification of the modules derives from a preliminary analysis of the requirements of a general-purpose interrogation scheme to extract judgments and comments rapidly and effectively from a group of geographically remote experts.

The range of options eventually needed will vary from being able to ask a highly structured set of questions of individuals at times of their own choice to running an open-ended parliamentary debate in real time. Additional requirements are posed because of the new modes of communication that are allowed. For example, the network allows conducting a structured conference where everyone speaks at the same time. Programs are needed to keep the simultaneous messages in order.

The specification of some of the modules must be kept open-ended until we have experimented with them and determined which procedures are of most

value to the system users. Thus, the general plan has each module capable
of being changed or deleted with minimal repercussion to the remainder of
the operating program. Because of the expectation of change, we are using
a ground rule that the written code have adequate comments interspersed so
that at least minimal documentation will survive the continual programming
changes envisioned.

RELEASES

The concept of module autonomy is more a goal than a reality. In prac-
tice it is difficult to change one module without reflecting changes else-
where. Therefore we have adopted the standard nomenclature of "releases"--
grouping individual changes so that major changes occur infrequently and the
user is always working with the last fully debugged release.

The releases are described in Sections III and IV. We are currently
operating under Release 2 and programming Release 3. As will be described,
we have sufficient mandatory improvements scheduled that will take us to
Release 5 within the year.

DOCUMENTATION STATUS

While documentation for the program development exists, it is primarily
in the form of notes and comments in the program listings themselves and
of highly simplified flow charts.

This documentation is adequate for the preliminary programming purposes
of the project but it is not yet suitable for detailed presentation in this
report without additional explanation.

As we have a sufficiently detailed description of the operation of the
programs in the next sections, we have chosen to defer full documentation
until after the evolution of the program stabilizes and to present it in the
next Technical Report.

III. PROGRAM DESCRIPTIONS

TEAMS

The system is based on the concept of a management team (consisting of a Chairman, an Umpire, and one or more Editors) together with a sizable group of expert respondents (called respondents or experts, interchangeably). Each person is assumed to have his own terminal: CRTs for the management team and either CRTs or hard-copy terminals for the respondents, whichever they may have available. (At this time we prefer that the respondents' terminals operate at 30 characters per second or higher to minimize interactive delays and that the terminals be full-duplex ASCII.)

DUTIES

It is the duty of the expert (respondent) to answer questions posed to him; to make suggestions; to argue; to comment on statements made by others; and to be free to introduce motions changing the procedures or directions of the inquiry.

It is the duty of the management team to keep the process going in an orderly direction.

The Chairman is the man with the problem. He is the executive decision-maker, who may be assumed to have little understanding of the computer system. The Chairman's assistant is the Umpire. The Umpire is the man traditionally thought of as the chairman in the usual parliamentary debate. It is the duty of the Umpire to answer procedural questions, to carry out the intent of the Chairman, and to conduct the inquiry. In general, it is only the Chairman who will know the substantive issues being discussed, and it is only the Umpire who will be fully acquainted with the capabilities and limitations of the system.

It is the duty of the Editor(s) to unburden the Umpire from being overloaded by the upward flow of simultaneous information from the respondents.

The Editor will indicate how each respondent's input is to be treated. For example, it may be an answer to a question, or a motion; if a motion, then type of motion. The Editor is usually the man to whom the respondent talks when he seeks help on any matter.

MANAGEMENT TEAM MOCK-UP

Since at present the Institute has only three terminals and two full-time people on the project, we have compressed the range of duties of the Chairman, Umpire, and Editor into a single hypothetical person at this stage of program development. This composite role is called "Chairman" until these duties are separated later in the program development cycle.

PROGRAMS

The respondent uses a program called EXPERT, while the Chairman uses a program called CHAIRMAN. These are high-level programs that in turn call up specific modules as needed. These programs now comprise about 7,500 lines of source code including a repertoire of information transferring, process-ing, and communicating subroutines as well as the usual utility programs.

Prior to the initiation of an inquiry session, it is necessary for the Chairman to prime the system by inserting files containing text for background information and for the list of questions to be asked. (The program for creating the background file is called CBKGF; the one for the question file is TPROC.)

The Chairman's Program

At all times, CHAIRMAN is either executing some command explicitly given by the investigator or else awaiting another such command. By means of these commands, the Chairman can call for various routines that monitor and direct the flow of the inquiry. These include, for example:

- a display showing which respondents are on the system, along with their terminal numbers and other identifying information;

- a display summarizing the progress of each respondent (or of the panel as a whole) through a particular question;

- a display showing the current status of the inquiry control switches*; and

- a routine to set these switches* and thus direct the flow of the inquiry.

In addition, the investigator can call a variety of text and numerical processing routines:

- a routine for replying to requests from individual respondents for specialized background data;

- routines to search the indexed files of input information for response "packages" of any given type, display these responses on the Chairman's terminal, and return selected responses to the panel;

- routines for rephrasing or deleting existing questions from, and introducing new questions into, the inquiry; and

- routines for gathering, processing, and displaying (in alternative formats) respondents' estimates of:
  - single numerical quantities, and
  - three-point probability distributions.

The Respondent's Program

The respondents are invited to join in the inquiry and told when and how to tie into the ARPANET and the chosen host computer, and to call program EXPERT.

Each respondent is given his own copy of program EXPERT. This program leads the respondent through the inquiry. Thus, the inquiry consists of a single CHAIRMAN program and a number of simultaneously operating EXPERT programs communicating to the CHAIRMAN program. The present Release 2 of the EXPERT program assumes that each respondent will answer each question in approximately simultaneous fashion. (This restriction will be removed in later releases.)

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*Changed to command word in Release 3.

The EXPERT program first provides the respondent with background information and then carries him to the main body of the inquiry where he is called on to answer questions previously posed by the Chairman in TPROC. In answering each question, the respondent may proceed through three phases: a question review phase, an extraction of verbal statements phase, and a numerical response phase. (In Release 3, bypassing of phases is permitted the respondent.)

Input provided by the respondents is stored in indexed files that can then be retrieved by processing and display routines at the choice of the Chairman.

Utility Programs

Routines have been written that perform various necessary functions without being called explicitly. These include, for example:

<u>Text Editing</u>. A text-editing routine is automatically invoked whenever any participant is asked to enter inputs at his terminal. This routine allows, for example, deletion of the last character, last line, or the whole input, and display of the last line or whole input.

<u>CRT Routines</u>. Several routines have been developed for some housekeeping functions of the CRT terminals used. These routines will, for example, clear the participant's screen prior to commencing a lengthy printout and, when the screen is full, pause for him to read that screenful (thus avoiding loss of information by "roll-off" at the top of the screen).

<u>"Help" Routines</u>. When a user gets into trouble, he merely types "help" (at present, ↑H). Special routines are thus invoked to establish a direct communications link between the terminals of the investigator and the respondent requesting help. Upon termination, the routines provide for automatic return to appropriate places in both main programs.

<u>File Access Routines</u>. These routines transfer text to and from indexed files under control of higher-level subroutines.

IV. PROGRAMS RELEASED TO DATE--SPECIFIC ACCOMPLISHMENTS

As mentioned previously, improvements to the programs and changes are grouped together for debugging, forming "releases." Each subsequent release is consecutively numbered; we are currently programming Release 3.

RELEASE 1

Release 1 was the first set of program packages that could be used to form a primitive working system. Since it has been superceded, it is described only for the project record:

1. It included the capability of simulating the answering of very simple questionnaires.

2. It efficiently provided fully asynchronous operation only.

3. It allowed only a single round of questions. (No means existed for presenting the results back to the respondents for their review and reappraisal.)

4. Its sequence of operations was essentially like that described in the previous section of this report.

RELEASE 2

Release 2 has been completed and is on file at both the RAND and BBN PDP-10 sites as a working program. It differs from Release 1 in the following ways:

1. It permits handling multiple rounds of the questionnaire.

2. The Chairman's command capabilities were expanded to allow displays for the whole inquiry rather than one topic at a time.

3. The topics were organized on a decimal tree structure of the form 1.1.1, 1.1.2, etc.

4. All text inputs are requested from the respondent by starting each line with a herald character, ">".

5. To provide a practical, user-oriented conferencing system, we have tried to make logging into and use of the conferencing system as

straightforward as possible. For easy reference, we have prepared a set of instructions on logging into and use of the conferencing system. Recovery procedures in case of failure are also included. It is hoped that, in the normal course of an inquiry, these instructions, in addition to the explicit instructions given by the system itself, should enable anyone to use the system conveniently.

6. The respondent can, at any time, exchange questions and messages with the Chairman by requesting a link connection.

7. Text editing (control letter-type) commands were adapted to be consistent with the convention used in TENEX (and TYMSHARE).

8. Samples of text for test demonstration purposes were simplified and clarified.

V. CURRENT PLANS--GENERAL PROBLEM AREAS

Much of the work during the next periods, aside from straightforward programming, concerns the following four topics: modes (synchronous/asynchronous), conferencing decision rules, unburdening the Chairman, and improving system reliability. These could be regarded as problem areas, but since their solution seems reasonably straightforward, we are inclined to think of work on these problems as normal work topics to be developed during the next phases of the effort.

MODES

We may divide the interactions of the Chairman and his panel of respondents into two timing categories or modes: synchronous and asynchronous. In the synchronous mode all respondents, for example, might answer the same posed question at the same time. In the asynchronous mode, each respondent would answer the question, but at a time of his own choosing.

The asynchronous mode lends itself more to the questionnaire-answering requirement, whereas the synchronous mode is required in a conference or debate operating under controlling procedures, such as *Robert's Rules of Order*.

To date, most of the work on the project has focused on the asynchronous mode, with work now beginning on the synchronous mode. Both modes will be required in the final system, and mixed operation is anticipated, with increasing attention given to the synchronous conferencing phase.

CONFERENCING DECISION RULES

There are logical decision rules to be developed to implement those modes where parallel upward communications from the respondents is anticipated, which go beyond the priority structure of *Robert's Rules of Order*. For example, *Robert's Rules of Order* were formulated to handle basically binary decisions: a "yes" or "no" vote on a specific motion. This system must also include the

capability of nonbinary decisions, such as the group's estimate of the state of the art of a certain technology during the next year, a more difficult formulation. We plan to explore this subject in more detail during the next periods of this project.

UNBURDENING THE CHAIRMAN

When everyone is allowed to talk simultaneously, a heavy information burden is placed on the management team. The degree of success of this system will depend, to a major degree, on success in being able to unburden the Chairman to keep the group's interaction moving along quickly and effectively. Major attention will be given to this requirement in the next periods of this project, including implementing the roles of the Umpire and Editor separately, as described earlier.

IMPROVING SYSTEM RELIABILITY

To be fully useful, the system must be highly reliable. Since we are concerned with overall system reliability of the entire conference, we must operate at reliability levels higher than those of the individual reliabilities of the TIPS and host computers--particularly better than that experienced to date.

One approach to be explored in the next phase is that of having the operating programs and files reside in two different computers, say the USC and the BBN PDP-10 installations. During the conference the back-up computer will interrogate the primary computer, "Are you alive and well?" If the answer is "no," the back-up computer will take over, communicating to the TIP and hosts involved at the time. This will require periodic file updates during the course of the inquiry to minimize lost information during the back-up.

We might handle the case of the failure of a TIP or local host serving as an input tie-in point by having the user call a secondary TIP and logging in again.

In any event, we plan to explore a range of automatic back-up alternatives to achieve a higher level of operational reliability than we are currently experiencing.

VI. CURRENT PLANS--FUTURE RELEASES

Much of the work in the next half year will be adding new modules. This will, to some extent, require revision of program developments already written. We prefer this incremental developmental approach because it permits earlier discovery of problems in the development cycle.

Below we describe improvements and additions that are scheduled for implementation in Releases 3 through 5 at this time.

RELEASE 3

We are currently operating under Release 2 while programming Release 3, our next scheduled release. It differs from Release 2 in the following ways:

1. A simple command language, comprising a few action verbs, allows the respondent more control of his passage through the inquiry. For example, it will permit the respondent to skip ahead if he is excessively bored with the background information being presented to him.

2. An interrupt capability is being added to halt output to allow faster response to user commands.

3. Adaptive instructions are being used to allow a little common sense to be exercised by the respondent. If the respondent demonstrates a competent acquaintance with the operation of the system and the subject matter of the inquiry, he is allowed to move through the process with less diversion for instructions than an obvious neophyte. These instructions will automatically adapt, based on measures of the user's skill, such as counting errors and successful trials.

4. A type-ahead capability is being added to permit the respondent to answer a question while waiting for the completion of an incoming verbose question statement.

5. There was a problem in the previous version when the respondent tried to speak to the Chairman and there was no Chairman there (as in the case where a person is stepping through the EXPERT program to see how it works--not during an exercise). Instead of being trapped and unable to return to the next stage of the program, he will be given the option of leaving a message and will then be returned to the continuation of the inquiry.

6. The program has better response when a user hangs up, or is disconnected midstream, by detecting loss of carrier.

7. A number of minor editing improvements are being made, including better use of the cursor addressing capability of the Hazeltine terminal for the Chairman and the addition of "control-W" to delete a word.

8. But, most importantly, the program is beginning to be modified in preparation for the synchronous conversational capability needed later. A program called CONVERSATION, in the form of an optional procedure during the debate phase of the questionnaire answering, allows a simple synchronous conversational capability.

RELEASE 4

Release 4 will build on Release 3 and add a number of new capabilities, including:

1. An expanded command repertoire for both the Chairman and the respondent will be added, with new routines to handle essentially all frequently needed operations. It will give the respondent complete flexibility of moving around his questionnaire. And, it will give the Chairman an improved capability for initiating various types and phases of the inquiry. (In Release 2, the Chairman exercised control when setting up the inquiry by choice of a number of binary key words. This was time-consuming and did not lend itself to rapid on-line changes.)

2. The Chairman, as currently constituted during the early stages of development, subsumes the roles of Editor and Umpire and, as a result, is partially overloaded. Over the course of program writing, the differentiated roles of the Editor and the Umpire will emerge with a division of roles and responsibilities as described earlier.

3. At present, the respondent is still relatively constrained in his freedom of action. Work has started on modifying the EXPERT program to allow the respondent to be more fully in command of his passage through the inquiry. This freedom of choice will be continued and expanded in this tentative release.

4. This release will include the first attempts of implementing *Robert's Rules of Order* in programs. The Editor will observe respondents' typed comments to see if they contain implicit requests for motions (or the respondent may make such motions explicitly). Once the motion has been identified, the system might handle it according to a prespecified hierarchy of what-might-interrupt-what. If the motion were out of order, it would be returned with the reasons. The initial version of this parliamentary conference program module will have a very small set of available motions--perhaps two or three. This list will be extended later as we feel our way along.

5. A number of minor improvements will also be implemented at this time. These include improvement of the printed format that is presented to the respondent (the present text format is awkward to read); addition of an automatic prodding response when the respondent takes too long on any single item; and the addition of a quick reformatting capability for those respondents whose numerical votes are on the extremes of the panel's distribution.

If performance of Release 4 is as expected, then it will be tested with up to about ten simultaneously operated, geographically distributed terminals.

RELEASE 5

Release 5 will follow on, or some of the items may be concurrently developed in Release 4, and will include the addition of the following capabilities:

1. It will provide recording means for the panelist's performance, such as elapsed time, time to respond (adjusted to his measured typing speed, terminal print rate, etc.), and frequency of errors and queries. As a starting point, a magnetic tape will be written of the entire inquiry, with start and stop times for each interaction. Playing back this tape will permit most measurements to be made after the inquiry without having to specify all the test parameters in advance.

2. It will provide better economy of storage use by mapping files into core only as needed (including programs themselves).

3. It will provide improved handling of feedback displays to the respondents, showing them results of previous rounds.

4. It will have an expanded set of activity modules developed from what has been learned in the tests with the ten remote respondents using Release 4.

5. It will improve the process that allows the Chairman to select sequences of activity modules easily, with particular emphasis on frequently used sequences.

6. All code will be converted to reentrant routines.

7. The control transfer program as described in Section IV, under "Improving System Reliability," in which a back-up computer is used, will be implemented.

8. It will allow any user to link to any other, if the Chairman permits.

9. Voice conferencing capability will be tested.